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## **The Need for Flexible Take-ups of Home Equity and Pension Wealth in Retirement**

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*Publication date:*  
2016

*Document Version*  
Publisher's PDF, also known as Version of record

[Link to publication in Tilburg University Research Portal](#)

*Citation for published version (APA):*  
Arts, J., & Ponds, E. (2016). *The Need for Flexible Take-ups of Home Equity and Pension Wealth in Retirement*. (Netspar Discussion Paper; Vol. 01/2016-005). NETSPAR.

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# The Need for Flexible Take-Ups of Home Equity and Pension Wealth in Retirement

Jori Arts and Eduard Ponds

DP 01/2016-005

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# The Need for Flexible Take-Ups of Home Equity and Pension Wealth in Retirement

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Jori Arts & Eduard Ponds

January 15, 2016

## Abstract

This paper analyzes for the Netherlands the need to introduce flexible take-ups of home equity and pension wealth, complementary to recent reforms in Dutch pensions and mortgages. The young may gain from supplementing a possible pension shortfall with additional retirement income from reverse mortgage contracts. The elderly may benefit of the innovation of partial lump sum of accrued pension rights in order to partly redeem mortgage debt, whilst maintaining an adequate net replacement rate from pensions.

# 1 Introduction

Two trends in retirement wealth components are being observed in the Netherlands, specifically in pension and housing wealth. Pension wealth will become more risky due to the gradual evolution of 2nd pillar pensions from defined benefit plans towards collective and individual defined contribution plans. These changes in plan type implies pension risks have to be borne increasingly by individual plans participants. Net home wealth at retirement on the other hand will become less risky as recently interest-only mortgages are forbidden. All new loans for home financing should be offered in the form of annuity mortgages. Moreover strict restrictions have been imposed regarding the annuity amount by defining maximum size of the loan-to-value and the maximum size of the income-to-loan value. These two opposing trends will have different impacts on different generations. Younger generations are faced with an imbalanced accumulation of wealth; there is a sizable chance of a low pension outcome in DC schemes, whilst the potential income from home surplus value is high for low loan-to-value annuity mortgages. Conversely, older generations may be confronted with large amounts of remaining mortgage debt due to homes financed with high loan-to-value interest-only mortgages, whilst having accrued a relatively certain pension in traditional DB schemes. In order to aid pension plan participants in realizing an adequate retirement income, there is a need for exchanging both wealth components by the use of flexible take-ups.

In this study, we analyze how flexibility in the exchange of housing and pension wealth, by the use of reverse mortgages and pension lump sums, may benefit different generations.

The structure of the paper is as follows. Section 2 provides a literature review on the trend from defined benefit towards defined contributions pensions, as well as on the interchangeable roles of pension and housing wealth in retirement. Section 3 outlines the model and methodology used in the simulation study of retirement income streams for current Dutch DB and prospective DC pension plan participants. Section 4 presents the simulated outcomes and assesses the benefits of flexibility in housing and pension wealth for different generations. In section 5, the paper is concluded with a summary of the analysis.

## 2 Pension and housing wealth in retirement

### 2.1 Interchangeable roles

For many households, home equity is the single most important asset in their portfolio. In 2013, 57.2 percent of Dutch households owned a house, with home value accounting for 56.7 percent of their total assets, on average (Statistics Netherlands, 2015). Financing a house by the use of a mortgage loan constitutes a large financial commitment for households: mortgage loans typically have an initial term to maturity of 30 years. Over the course of their pre-retirement life, households forgo consumption by making payments to their mortgage balance, implicitly saving for the future through their net housing wealth. That is, home ownership implies prepayment of future housing consumption. One of the main intuitions of life cycle theory is that asset accumulation (in this case housing wealth) is not a goal per se, rather it is a means of accomplishing consumption smoothing over time. From the perspective of optimal consumption smoothing, it would be beneficial for retirees to gain access to the large part of housing wealth that they have saved for during their working life. In reality however, Romiti & Rossi (2012) find that very little decumulation of housing wealth is observed after reaching retirement age, when depletion should optimally occur. The choice of retaining instead of consuming housing wealth throughout retirement can be attributed to a number of factors.

First and foremost, home equity is an illiquid asset, which usually can only be liquidated at high cost. In order for households to unlock the value in their home, the traditional means of downsizing (selling and living smaller) or renting may also be unfavorable if retirees simply wish to remain in their self-owned residence, unwilling to move from a home they are attached to. Also, in the presence of a bequest motive there may be less propensity to consume housing wealth during retirement. Thirdly, in a survey conducted among Dutch households, Toussaint & Elsinga (2010) find that older people generally do not wish to consume their home equity, but rather hold on to it as a precautionary buffer. Owner-occupied housing is used as a form of insurance; in the event of an income or health downturn, or widowhood, home equity may be cashed out to

supplement base retirement income (Skinner, 1996). This precautionary savings motive of the current older generations could potentially be explained by the sufficient pension benefits accrued in the traditional Dutch defined benefit pension schemes (in addition to the flat-rate pension provided by the state), where the pension fund runs the investment risk, and the outcome is fixed. However, pension policies in the Netherlands have changed: current working generations face the likelihood of less generous pensions and more pension risks being shifted to them.

Following the international trend from defined benefit towards defined contribution pensions (Baily and Kierkegaard (2009)), traditional DB plans have become far less common in the Netherlands over the past decade. Even though Dutch occupational pension plans have mainly preserved their DB character, current pension plans may be better viewed as hybrid DB-DC schemes. Following the solvency crisis in 2001-2004, Dutch final-pay plans with unconditional indexation have made way for average-wage plans with solvency-contingent indexation. Such hybrid plans are partly DB because of the yearly accrual of pension rights and the contribution rate as steering instrument; whilst partly DC, since indexation is dependent on the funding ratio and thus related to investment returns (Ponds & van Riel, 2009). Some pension funds have gone one step further from defined benefit design by abolishing the flexible contribution rate, known as collective defined contribution schemes with a fixed contribution rate and flexible benefits. Collective defined contribution schemes lack the risk-steering instrument of contributions rates, leading to greater variability in pension outcomes for participants. In the wake of the 2007-2008 financial crisis, long-term interest rates have continuously declined over the years, leaving pension funds struggling to meet their liabilities. And unlike the key characteristic of 'defined' benefit funds, in the early 2010s pension rights were cut on an unparalleled scale, when recovery contributions were not sufficient in improving the solvency of pension funds. In the current Dutch debate of more freedom of choice in pensions, it is likely pension risks will continue to be shifted to participants to allow for more individual decision making. Hence, younger generations will be faced with higher uncertainty surrounding their pension income.

In contrast to the increasing probability of a pension shortfall, stricter housing policies have forced younger generations to save more out of their own pocket to finance a house, making a housing windfall at retirement more likely. Since the 2007-2008 financial crisis, house prices in the Netherlands have declined by approximately 21 percent until early 2014, leaving a substantial number of Dutch households with a mortgage debt exceeding the market value of their home. Early 2008, 13 percent of homeowners had negative housing wealth compared to a staggering 34 percent early 2013. Also the average value of mortgage debt in excess of home value has increased, from €52000 in 2012 to €61000 in 2013, an increase of 17 percent within one year (Statistics Netherlands, 2014). In

order to improve the financial stability of borrowers and lenders on the Dutch housing market, major reforms have been undertaken. In a study conducted by the Dutch Central Bank (2014), the average repayment rate on mortgage loans (contract based) for young homeowners is found to be close to 80 percent, compared to approximately 20 percent for current retirees as shown in Figure 2.1.

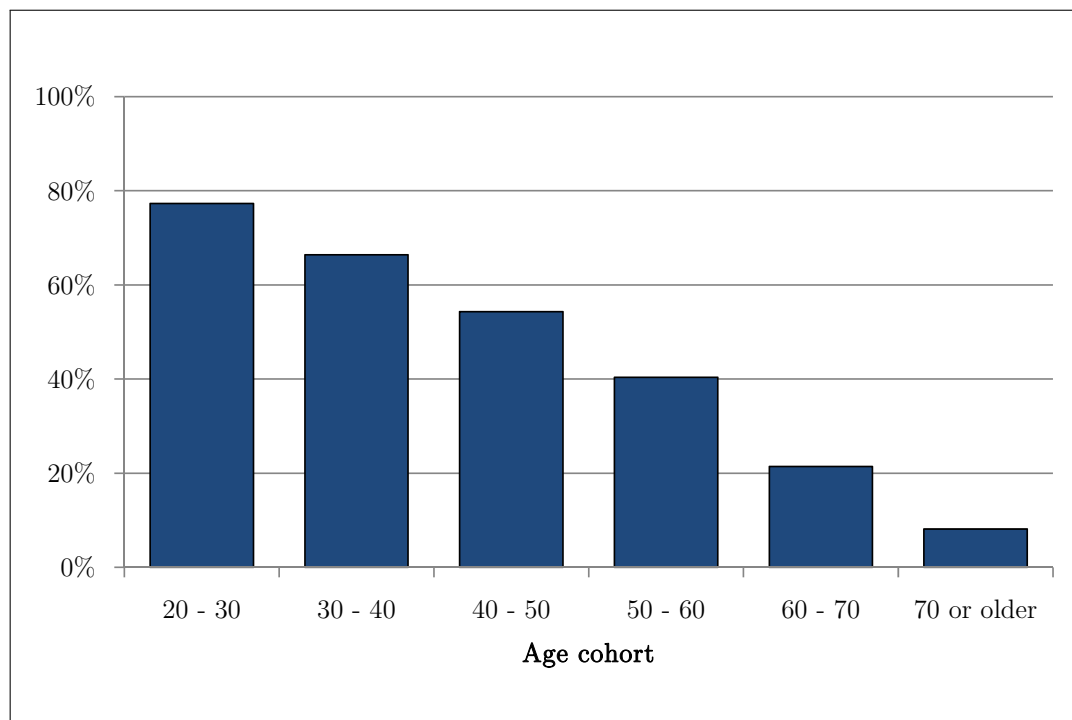


Figure 2.1: Average mortgage repayment rate per age cohort

End of september 2013. *Source:* Dutch Central Bank (2014).

The difference in repayment rates between age cohorts is mainly explained by the type of mortgage loans being issued (see Figure 2.2). Overall, 35 percent of Dutch homeowners have financed their purchase with an interest-only mortgage for the entire home value, whereby no periodic repayments to the principle are made, and no underlying assets are accumulated to pay off the mortgage at maturity (a typical savings-based mortgage). Mainly older generations have taken out an interest-only mortgage; 58 percent of homeowners aged 50 and over have financed their initial home purchase entirely with an interest-only mortgage, compared to 15 percent for those younger than 50. Due to stricter regulation of home financing, new interest-only mortgages may only be issued at a maximum of 50 percent of the home market value. Also changes in fiscal policy – new homeowners may only deduct mortgage interest from taxable income for linear and annuity mortgages – have lead households to pay off their mortgage periodically instead of deferring repayment at maturity of the loan term. Apart from the trend of increased ‘saving’ *during* the term of the mortgage loan, young households are also required to save more *prior* to taking out a mortgage loan. In the Netherlands, the maximum loan-

to-value ratio is gradually being decreased to 100 percent in 2018, with prospects of a further decline to 90 percent, suggested by Dutch supervisory authorities. Following this decline, it is estimated that future homeowners should save three additional years to be able to afford a house, on average (Dutch Central Bank, 2015).

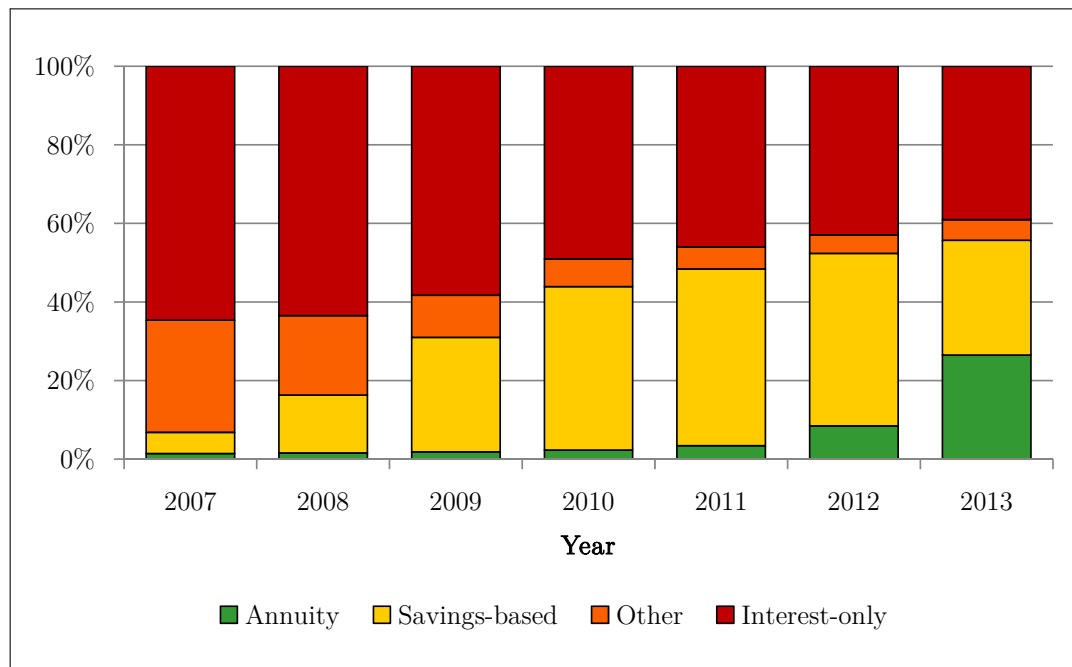


Figure 2.2: Composition of new mortgage loan issues

End of september 2013. *Source:* Dutch Central Bank (2014).

It can be concluded that two trends in retirement wealth components are being observed, specifically in pension and housing wealth. Figure 2.3 visualizes the trends from risky to less risky home financing and from low risk to high risk pension capital accrual. Flexibility in the take-up of pension and housing wealth may benefit participants. Younger (and future) generations could benefit from liquidating the relatively certain surplus value in their home to compensate the increasing chance of a pension shortfall (see ①). Older generations could benefit from flexibility as well by allowing them to take out a (partial) lump sum of their pension rights in order to pay off debt on interest-only mortgages (see ②). Next, we discuss how flexibility in the take-ups of home equity and pension wealth can be facilitated.



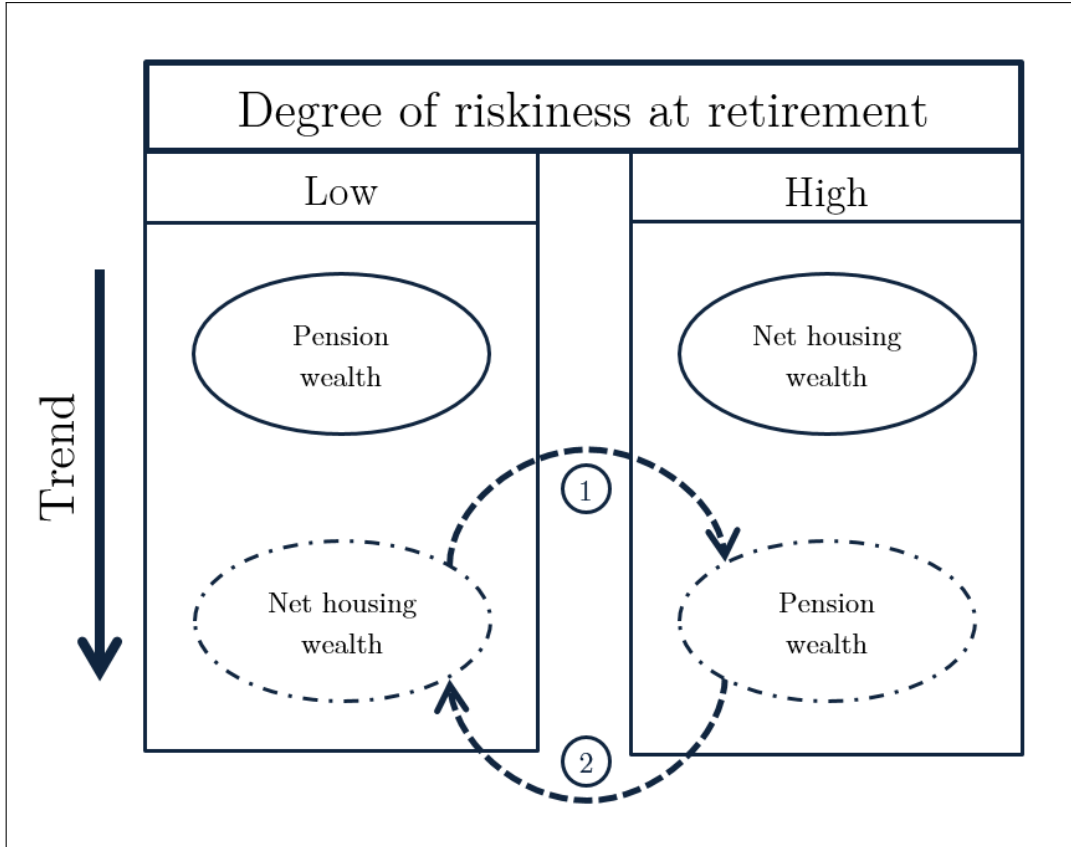


Figure 2.3: Visualization of trends in pension and housing wealth

This figure visualizes the effects of trends in pension and housing policies on the degree of riskiness of wealth components at retirement. An increase in the riskiness of pension wealth is observed, due to the shift in risks from the collective to the individual. Whilst net housing wealth is becoming less risky due to mandatory saving by the increasing use of lower loan-to-value annuity mortgages. Hence, younger generations (①) may benefit from liquidating net housing wealth in order to supplement pension wealth in case of a shortfall. Older generations (②) can be offered flexibility as well by providing them with the opportunity to withdraw a lump sum of their pension wealth to pay off an outstanding interest-only mortgage loan balance.

## 2.2 Housing wealth: Reverse mortgage

For younger generations, the use of reverse mortgages can be an effective way of unlocking the surplus value in their homes. Reverse mortgages allow homeowners to borrow against the equity accumulated in their home without being forced to move out and sell the house. Whereas in a conventional mortgage the homeowner makes periodic payments to the lender in the form of interest and debt repayment, a reverse mortgage requires neither interest nor repayment for as long as the homeowner lives in the house (Mayer & Simons, 1994). Since the elderly homeowner may need to liquidate his housing wealth precisely because base retirement income is not sufficient in maintaining living standards, it is likely a second mortgage would not be affordable. Instead, interest on the reverse mortgage is added to the loan balance, providing the homeowner with a higher degree of

liquidity during retirement. When the homeowner moves permanently, sells the house, or passes away, the loan is repaid with the proceedings of the house sale. We discuss some of the major advantages reverse mortgages provide over the traditional means of liquidating housing wealth.

Firstly, reverse mortgages allow homeowners to tap home equity whilst staying in their current home. The option of selling the home and living smaller has several drawbacks. Typically large transaction costs are associated with home sale, as well as a relative downgrade in housing consumption since housing wealth is partly retained instead of potentially consumed. In addition, traditional means of liquidating housing wealth do not account for a house price appreciation during the contract term, which limits the amount of money that can be borrowed compared to a reverse mortgage. Dillingh, Prast, Rossi, & Brancati (2015) note that there may also be psychological costs associated with moving out of a self-owned residence. Even when homeowners reach an advanced age and their health deteriorates, most households intend to stay in the house they have already been living in for many years; suggestive of a strong reluctance to move (Rouwendal, 2009). Secondly, reverse mortgages provide optimal bequest timing for homeowners with a wish to bequeath housing wealth to their heirs. Even though a bequest motive may reduce the interest in the use of reverse mortgage products from the perspective of an elderly homeowner, it could actually improve the heirs' welfare. Merton (2008) states that reverse mortgages can be a far more efficient way of creating a bequest than holding onto a house and leaving it to heirs. From the point of view of the heirs' utility, receiving the house as a legacy at an uncertain point of time in the future is likely to be far from an optimal bequest policy. By entering into a reverse mortgage contract, housing wealth may thus also be partly bequeathed prior to the homeowner's death, potentially improving the heirs' welfare. In addition, if the homeowner passes away, the heirs have the right to the residual housing wealth after loan repayment, even if the borrowed amount is annuitized (which typically comes at the cost of higher interest rates). Oppositely, the lender cannot claim funds from the heirs for repayment of the loan if the house sells for less than what was borrowed. Thus, even in the presence of a bequest motive, reverse mortgages can provide an effective way of bequeathing housing wealth.

Despite the benefits that reverse mortgages provide, the market in the Netherlands has been very thin. Shan (2011) claims that house-rich but cash-poor elderly homeowners who cannot obtain conventional home equity loans should be interested in reverse mortgages in order to gain access to illiquid housing wealth. Poverty levels among the elderly in the Netherlands are actually relatively low (Knoef et al. 2014, OECD 2013). The traditional Dutch pension system provides good protection against old-age poverty through its first pillar flat-rate benefit. The income-related second pillar supports the elderly in maintaining their living standards after retirement. Hence, the demand to gain

access to illiquid housing wealth in order to supplement base retirement income by the use of reverse mortgage products has been generally low. With pension income becoming less generous and pension risks being increasingly shifted towards participants on the one hand, whilst tightening regulation of home financing forcing mandatory saving on the other hand, the need for flexibility in exchanging home equity for pension wealth by the use of reverse mortgages is expected to become more prominent in the near future. Therefore, the suggestion is that housing wealth could become increasingly important for households' financial strategies for old age.

## 2.3 Pension wealth: Lump sum

For older generations, withdrawing accrued pension rights in the form of a lump sum can prove useful in reducing the loan balance on interest-only mortgages. Currently, the majority of participants in Dutch collective pension schemes accrue benefits based on an average-wage scheme. That is, each year benefits are accrued based on a participant's wage level. The accrued benefit is expressed as a deferred annuity, to be received at retirement age. By law, participants are not allowed to convert pension entitlements to a lump sum payment; there is a possibility to have a higher or lower annual benefit in the early retirement years, though it is infeasible to use this option to redeem mortgage debt due to limitations. Hence, current homeowners nearing retirement may be confronted with generous annual retirement income (due to a history of participation in traditional DB), but high mortgage interest expenses (due to no periodic mortgage payments). By allowing (partial) lump sums for mortgage redemption, elderly homeowners are able to significantly reduce their debt position, increasing the likeliness of refinancing by banks if necessary. In addition, by redeeming mortgage debt interest expenses during retirement can be cut. Whether this option is welfare-enhancing depends on both the return on pension wealth (indexation) as well as the net interest rate on mortgage loans. Since mortgage interest is tax-deductible, using pension savings to pay off mortgage debt will only be beneficial if the net interest rate is higher than the return on pension wealth; that is, the expected indexation to be received if pension benefits are kept in the pension fund (Kortleve & Loois, 2014). In recent years, this hasn't been the case. Though it is important to note that the return on pensions is (becoming increasingly) uncertain whilst mortgage interest rates are not (apart from interest rate revisions). In addition, the Dutch government is gradually decreasing fiscal benefits of mortgage interest deduction by lowering the deductible amount as well as setting a limit on the number of years (currently 30) homeowners may deduct interest expenses. These changes make the take-up of pension entitlements as a lump sum all the more attractive for elderly homeowners.

## 3 Methodology

In the previous section we have extensively discussed the implications of the trends in pension and housing policies in the Netherlands, and the effect on different generations of pension plan participants. In order to aid participants in the changing environment of pensions and housing, there is a need for flexible take-ups of home equity and pension wealth. In this section we outline the components of the analysis. Firstly, we define two participant types: a young participant with the prospect of a risky pension, but certain home surplus value (a DC pension, and annuity mortgage), and an older participant expecting a more certain pension, but a risky mortgage debt position (a DB pension, and interest-only mortgage). Secondly, the mechanics of flexible take-ups of home equity and pension wealth are described (reverse mortgage and lump sum, respectively), which aid both participants in different ways. Lastly, the evaluation criteria for the use of both take-ups are defined. The model used in the empirical analysis is described in the appendix.

### 3.1 Participant types

Following the trend from traditional defined benefit pension schemes to hybrid DB-DC and collective DC schemes, with prospects of individual DC elements, pension wealth at retirement is becoming more risky for participants due to less risks being borne by plan sponsors. Conversely, following the trend from high loan-to-value interest-only mortgages to low loan-to-value annuity mortgages, net housing wealth at retirement is becoming less risky due to mandatory saving. These two opposing trends have different impacts on different generations. Hence, we model two participant types: a young participant with the prospect of risky pension, but certain home surplus value (a DC pension, and annuity mortgage), and an older participant expecting a more certain pension, but a risky mortgage debt position (a DB pension, and interest-only mortgage).

The young participant accrues pension benefits in a combined collective/individual DC scheme, following the trend from DB to DC with increased individualization. From the age of 25 until retirement age 67, pension benefits are accrued based on a fixed accrual rate in the collective DC scheme. Benefits may be positively and negatively adjusted

depending on the scheme's funding ratio. In addition, assets are accumulated in the individual DC scheme; at retirement age, the total asset value is used to purchase a single life annuity. The old participant is modeled as having a long history of entitlements in a traditional DB scheme. From the age of 25 until 60, accrued rights (based on the same fixed accrual rate) are indexed for wage inflation each year. That is, funding risks are absorbed by the plan sponsor, not the participant. At age 60, the participant experiences a change in pension system design to that of the previously described collective/individual DC scheme. Such a change resembles the possible introduction of DC elements in the Dutch occupational pension system. Whereas the younger participant can be regarded as an entrant to the new DC scheme, the older participant can be viewed as part of the transition generation from DB to DC. In Figure 3.1 below, we present the projected replacement rate distributions for both participant types, based on the simulations generated by the model (see the appendix for details). In expectation, the replacement rates of both participants are quite similar: the mean replacement rates are 63.3% and 62.7%, for the young and old participant respectively. However, a large difference in riskiness is observed: the respective volatilities are 8.9% and 2.4%.

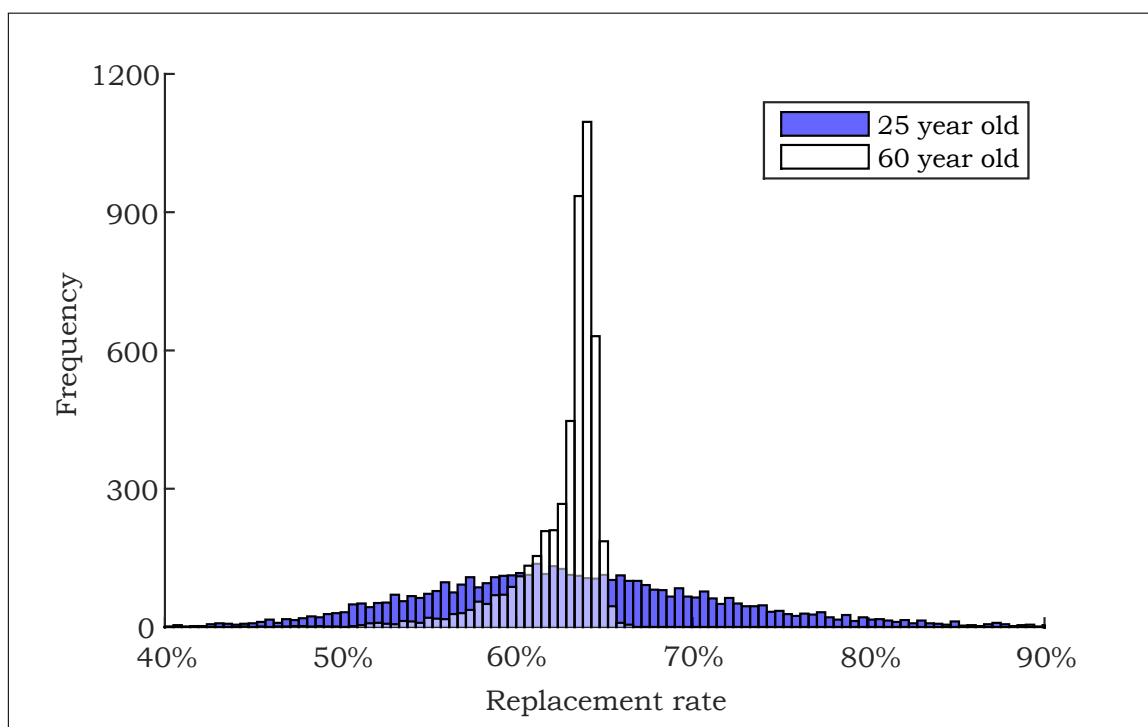


Figure 3.1: Replacement rate distribution for two participant types

This figure projects the replacement rate distribution at retirement age for a participant in a DC scheme from the age of 25 until 67, and a participant with a history of accrued entitlements in a DB scheme until the age of 60, changing to DC thereafter until 67. The expected replacement rates are quite similar (63.3% and 62.7%, respectively), however the degree of riskiness differs tremendously (8.9% and 2.4%, respectively).

Even though the young participant faces a high degree of uncertainty surrounding his pension income, the opposite holds for his expected net housing wealth (v.v. for the old participant). Following the trend from high loan-to-value interest-only mortgages to low loan-to-value annuity mortgages, net housing wealth at retirement is becoming less risky due to mandatory saving. An interest-only mortgage does not require periodic payments to the loan balance, instead, the borrower is required to pay off the entire mortgage debt at maturity of the loan. Consequently, the value of net housing wealth is strongly dependent on the appreciation of house prices over time. An annuity mortgage however, does require the borrower to redeem mortgage debt over time. Each period a fixed amount consisting of both interest and principle payment is paid to the lender, such that at maturity the loan is paid off entirely. In Figure 3.2, five scenarios of net housing wealth are plotted, for both an interest-only and annuity mortgage. Whereas the evolution of net housing wealth appears to be rather stable in all scenarios for the young participant with an annuity mortgage (due to mandatory saving), in reality house prices make large swings leading to uncertainty in home equity for the old participant, as is clear from the interest-only scenarios. Thus, both participants may benefit from flexible take-ups of pension and housing wealth by exchanging one for the other.



Figure 3.2: Evolution of net housing wealth for two mortgage types

This figure plots the evolution of net housing wealth for an interest-only and annuity mortgage, for the same five scenarios. The initial house value is based on a loan-to-income of four-and-a-half and is financed by 100% debt. The simulations are based on the model and scenario set, defined in the appendix. Whereas for the interest-only mortgage, mortgage debt exceeds home value at retirement age for all scenarios, home equity is abundant for the annuity mortgage due to periodic repayments.

## 3.2 Evaluation criteria

In order to assess the potentials (and limitations) of flexible take-ups of home equity and pension wealth by the use of reverse mortgages and pension lump sums, earnings replacement rates are analyzed. Replacement rates are calculated by comparing the level of pension benefits at the time of retirement to immediate pre-retirement labor income, thus showing what percentage of earnings is 'replaced' by benefits. This is a common approach in the literature to report on pension adequacy (Knoef et al., 2014, (Aldrich, 1982)). The calculation of the replacement rate is shown in Equation (3.1).

$$RPR_{i,R} = \frac{P_{i,R}}{Y_{i,R}} \quad (3.1)$$

where  $RPR_{i,R}$  is the replacement rate for participant  $i$  at the time of retirement  $R$ ,  $Y_{i,R}$  the immediate pre-retirement labor income, and  $P_{i,R}$  the total pension benefit. The total pension benefit, in principle, consists of the first pillar state pension as well as the second pillar earnings-related pension. The main factor influencing the composition of the replacement rate is the pension base of a participant, the pensionable salary minus the first pillar AOW franchise. Since the first pillar provides a flat-rate retirement benefit, the higher one's wage, the larger the relative size of the second pillar becomes due to its relation to earnings. For this reason, financial dependency on the first or second pillar will depend on a participant's lifetime labor earnings.

Comparative studies of social security and pension systems often use replacement rates as the basis for ranking outcomes; the rationale is that replacement rates provide consistent measures of the relative level of benefits across countries or individuals (Whiteford, 1995). In our analysis, replacement rates provide a measure of the (in)adequacy of pension benefits in maintaining pre-retirement living standards. By specifying replacement rate targets and subsequently analyzing simulated replacement rate distributions, we show how changes in pension policies (the trend from traditional DB to collective & individual DC) have increased the probability of a pension shortfall at retirement. Oppositely, due to stricter housing policies of increased self-financing via mandatory saving (the trend from interest-only to annuity mortgages), a housing windfall has become more likely. By expressing both pension and housing wealth as a replacement rate, we show to what extent the consolidation of a pension shortfall with a housing windfall (or vice versa) through the flexible take-up of home equity (or v.v. pension lump sum), can improve the financial well-being of individuals.

## 4 Results

In this section we analyze the potentials of flexible take-ups of home equity and pension wealth by the use of reverse mortgages and pension lump sums, based on simulations of projected retirement income. We observe for the Netherlands two trends in retirement wealth components: pension wealth and housing wealth. Following the trend from traditional defined benefit pension schemes to hybrid DB-DC and collective DC schemes, with prospects of individual DC elements, pension wealth at retirement is becoming more risky for participants due to less risks being borne by plan sponsors. Conversely, following the trend from high loan-to-value interest-only mortgages to low loan-to-value annuity mortgages, net housing wealth at retirement is becoming less risky due to mandatory saving. These two opposing trends have different impacts on different generations, hence the need for flexibility in exchanging both wealth components for one or the other will differ as well. Younger generations are faced with an imbalanced accumulation of wealth; there is a sizable chance of a low pension outcome in collective DC/individual DC schemes, whilst the potential income from home surplus value is high. Conversely, older generations may be confronted with large amounts of remaining mortgage debt due to homes financed with high loan-to-value interest-only mortgages, whilst having accrued generously indexed pension rights in traditional DB schemes.

Younger (and future) generations could benefit from liquidating the relatively certain surplus value in their home to compensate the increasing chance of a pension shortfall. Older generations could benefit from flexibility too by allowing them to take out a partial lump sum of their pension rights in order to pay off debt on their interest-only mortgages. In the two subsequent sections, we assess to what extent flexibility can contribute to an adequate pension for the young, and a reduced mortgage indebtedness for the old.

### 4.1 Housing wealth: Reverse mortgage

We analyze the projected retirement income for a young participant that accrues pension benefits in a combined collective/individual DC scheme, following the trend from DB to DC with increased individualization. In the collective DC scheme, the participant accrues pension rights based on a uniform accrual rate with a fixed contribution rate.



Indexation is conditional on the solvency of the fund and funding risks are absorbed by the adjustment of benefits, smoothed over time (a form of risk sharing). The collective DC indexation policy is split up into several funding ratio thresholds. Depending on the financial position of the fund, accrued benefits can either be cut, conditionally indexed, or fully indexed for wage inflation. In addition, the participant accumulates assets in an individual DC scheme which features a higher degree of riskiness in pension outcomes. During the accumulation phase, investment risk is entirely borne by the participant; at retirement age, accumulated assets are used to purchase a single life annuity, exposing the participant to interest rate risk. For the individual DC scheme we assume the same asset allocation policy (40% equities, 60% bonds) and contribution policy (10% in each scheme) as the collective DC scheme.

In Figure 4.1, the projected distribution of replacement rates are displayed for the young participant, based on the simulation model. A great variability in potential pension outcomes can be seen, resulting from pension risks being borne by the participant instead of being absorbed by the plan sponsor in a traditional DB scheme. Due to the high volatility in possible outcomes there is a sizable chance of attaining a replacement rate below 60%, which can be considered low.

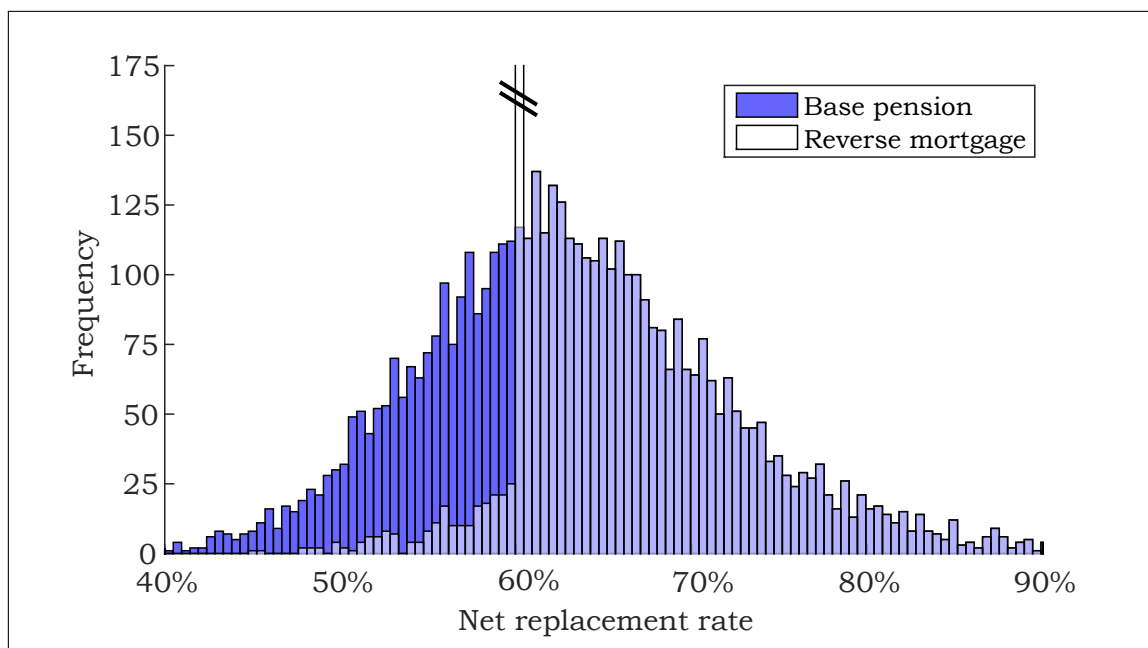


Figure 4.1: Supplementing base pension income with a reverse mortgage

This figure plots the distribution of replacement rates at retirement age for a participant in a collective/individual DC scheme for the entire accumulation phase. There is a clear distinction between the base replacement rate obtained from the first and second pillar pension, and the supplemented replacement rate (overlapping) obtained from the use of a reverse mortgage. The target net replacement rate is set to 60%, the reverse mortgage limit is fixed at 60% of net housing wealth at retirement age. Note that the white bar at the target replacement rate is cut off, the actual frequency of reaching the exact target is 1602, corresponding to a 32% probability.

In order to aid participants in realizing an adequate replacement rate in case of a pension shortfall, younger generations can benefit greatly from the use of reverse mortgages. Due to tightening regulation of home financing, young homeowners are increasingly required to pay off their mortgage debt periodically instead of deferring repayment at maturity of the loan. Hence, young homeowners are expected to possess a large amount of mortgage-free housing wealth at retirement. In our analysis we assume the participant has paid off their entire mortgage debt at retirement (a full annuity mortgage, home value of four-and-a-half times labor income at age 37, time to maturity of 30 years, with a loan-to-value of 100%), and is thus able to tap home equity to supplement base pension income. We show the effect of liquidating housing wealth on the net replacement rate at retirement age in Figure 4.1. The target net replacement rate of the young participant is set to 60%; that is, if a scenario of a gross replacement rate below 60% materializes (where gross implies pension-only), the participant will opt to use a reverse mortgage in order to attain the net target. At a reverse mortgage cap of 60% of net housing wealth, the net replacement rate can be substantially improved. In Table 4.1 we present the relevant statistics of attaining a certain target net replacement rate under the constraint of a reverse mortgage cap.

Table 4.1: Replacement rate statistics

This table presents the statistics of attaining a net replacement rate target given that the amount of net housing wealth that can be liquidated is constrained. The net replacement rate ( $RPR$ ) is defined as the replacement rate from first and second pillar pension, supplemented by annuitized net housing wealth. The value at risk and expected shortfall of the replacement rate are quoted at the five percent level. Since the reverse mortgage amount (as a percentage of net housing wealth) is constrained, a participant will not always reach their desired target (denoted by  $p(RPR < x\%)$ ). The bottom rows show the mean reverse mortgage amount ( $\mu(RM)$ ) and the probability that the demanded amount has reached the given cap ( $p(RM = cap)$ ), respectively.

	Reverse mortgage								Base pension
	60%				70%				
Net $RPR$ target									-
Rev. mortgage cap	30%	40%	50%	60%	30%	40%	50%	60%	-
Mean net $RPR$	64.6%	64.8%	65.0%	65.1%	67.3%	68.2%	69.0%	69.6%	63.3%
Std. dev. net $RPR$	7.5%	7.2%	7.0%	6.9%	7.1%	6.5%	6.0%	5.5%	8.9%
Value at risk	55.3%	57.1%	58.7%	60.0%	55.3%	57.1%	58.7%	60.0%	50.0%
Expected shortfall	51.9%	53.5%	55.1%	56.7%	51.9%	53.5%	55.1%	56.7%	46.8%
Minimum	40.5%	42.0%	43.5%	45.0%	40.5%	42.0%	43.5%	45.0%	36.0%
$p(RPR < 60\%)$	14.8%	9.8%	6.7%	4.5%	-	-	-	-	36.5%
$p(RPR < 70\%)$	-	-	-	-	56.5%	47.4%	38.1%	29.7%	79.9%
$\mu(RM)$	20.3%	23.6%	25.8%	27.4%	26.0%	32.5%	37.8%	42.0%	-
$p(RM = cap)$	40.4%	26.8%	18.2%	12.3%	70.8%	59.4%	47.7%	37.2%	-

Consider the aforementioned case where the participant would like to attain a replacement rate of 60% or higher upon reaching retirement age. As shown in Table 4.1, the probability of not reaching that target is estimated at 36.5%, which corresponds to the dark-colored surface on the left hand side of the distribution in Figure 4.1. In order to attain the desired replacement rate, the participant has the option to unlock the value in their home by taking out a reverse mortgage. In this example we fix the maximum lump sum of net housing wealth that can be borrowed at 60%. For each economic scenario, we assess whether the desired replacement rate has been reached; if so, the participant does not enter into a reverse mortgage contract. If not, it is calculated what share of net housing wealth (in annuitized form) is required to supplement the replacement rate up to the target. We find that the average amount borrowed is 27.4%, and that only in 12.3% of the cases the participant is required to borrow the maximum amount of 60%. By tapping home equity the probability of a pension shortfall has been reduced from 36.5% to 4.5%, as shown by the light-colored surface of the distribution in Figure 4.1. In addition, we find that the expected replacement rate in the five percent worst cases of possible future states is 56.7% compared to 46.8% without using a reverse mortgage.

All in all, we can conclude that younger generations that will be faced with higher uncertainty surrounding their pension income could benefit greatly from entering into a reverse mortgage contract by borrowing against their mortgage-free housing wealth in order to compensate a pension shortfall.

## 4.2 Pension wealth: Lump sum

Flexibility in exchanging home equity and pension wealth may not only benefit young homeowners, but also the elderly, in an opposite way. In this section we explore the potentials of flexibility for an older participant nearing retirement age: redeeming mortgage debt by withdrawing a partial lump sum of pension wealth. We analyze the projected retirement income for an older participant that has a history of accrued pension benefits in a traditional DB scheme, but experiences a change in pension system design at age 60 to that of the previously described collective/individual DC scheme. This change resembles the possible introduction of DC elements in the Dutch occupational pension system. Until the age of 60, the participant accrues pension benefits much similar to that of the previously defined collective DC scheme. However, in the traditional DB scheme each year accrued benefits are unconditionally indexed for wage inflation; funding risks are entirely absorbed by the plan sponsor instead of being shared by the participants. At age 60, the scheme changes to that of the collective/individual DC design. Whereas the younger participant can be regarded as an entrant to the new DC scheme, the older participant can be viewed as part of the transition generation from DB to DC. Hence, the

latter will have a pension portfolio consisting mainly of their DB entitlements and partly of their DC account. Due to the nature of defined benefit accrual, the older participant is much more certain of his expected pension income at retirement age.

However, the opposite holds for the participant's net housing wealth. In our analysis we assume the participant has not made any periodic repayments of mortgage debt up until retirement (a full interest-only mortgage, home value of four-and-a-half times labor income at age 37, time to maturity of 30 years, with a loan-to-value of 130%), which is typical for current elderly homeowners (see Section 2.3). Hence, the elderly homeowner nearing retirement is expected to have generous annual pension income (due to a history of participation in traditional DB), but high mortgage debt (due to no periodic mortgage payments). For older generations with large shares of interest-only mortgages, withdrawing accrued pension rights in the form of a partial lump sum can prove very useful in reducing their debt position. By reducing mortgage indebtedness, refinancing options may open up, allowing elderly homeowners to remain in the home they are attached to. In Table 4.2 we show to what extent an older participant can redeem outstanding mortgage debt at retirement age by taking a partial lump sum of second pillar pension wealth.

Table 4.2: Mortgage redemption statistics

This table presents the statistics of attaining a mortgage redemption target of an interest-only mortgage due at retirement age. The mortgage redemption ( $RD$ ) target is defined as the relative share of outstanding mortgage debt the participant would like to pay off using pension wealth. By taking a lump sum to redeem mortgage debt (Mean  $RD$ ), the gross replacement rate decreases (Mean  $RPR$ ). On the other hand, mortgage interest expenses decrease as well due to less outstanding debt. The interest expense is calculated as the 10-year interest rate plus a spread of 2.5%. Since participants can only take a partial lump sum, the desired redemption target will not always be reached (denoted by  $p(RD < x\%)$ ). The bottom rows show the mean pension lump sum amount ( $\mu(LS)$ ) and the probability that the demanded amount has reached the given cap ( $p(LS = cap)$ ), respectively.

	Pension lump sum						Base pension
	30%			50%			-
Mortgage $RD$ target							-
Lump sum cap	10%	15%	20%	20%	25%	30%	-
Mean $RPR$	58.0%	55.7%	54.7%	53.4%	51.1%	49.6%	62.7%
- Interest	15.2%	13.6%	12.9%	12.0%	10.4%	9.4%	18.5%
= Net $RPR$	42.8%	42.1%	41.8%	41.4%	40.7%	40.2%	44.2%
Mean $RD$	17.5%	26.2%	29.9%	34.9%	43.6%	49.2%	-
$p(RD < 30\%)$	100.0%	24.9%	0.4%	-	-	-	-
$p(RD < 50\%)$	-	-	-	100.0%	62.8%	5.5%	-
$\mu(LS)$	10.0%	14.9%	17.2%	20.0%	24.9%	28.3%	-
$p(LS = cap)$	100.0%	97.8%	5.5%	100.0%	97.8%	25.0%	-

Assume the interest-only mortgage is due for payment at retirement age. Over the course of the pension accumulation phase, no payments to the loan balance have been made. To settle the debt, the homeowner could either move out and use the proceedings of the home sale (if net housing wealth is positive), or redeem part of the debt by the use of a pension lump sum in order to be eligible for refinancing. We consider the latter case. The first and second pillar pension yield an expected replacement rate of 62.7% with a volatility of 2.4%. The variation in possible pension outcomes is low, since the older participant is mainly dependent on benefits accrued in the traditional DB scheme. The ambition of the participant is to redeem at least 30% of mortgage debt by taking a partial lump sum of second pillar pension wealth (converted from an annuity); in this example the maximum amount of entitlements that can be converted to a lump sum is capped at 20%. For each economic scenario, we assess to what extent the mortgage redemption target can be reached given the maximum lump sum imposed by the pension fund. If the desired target can be reached, the participant may not have to utilize the maximum lump sum amount. For the aforementioned case, we find that the average amount of mortgage redemption is 29.9%; only in 0.4% of the cases the participant is not able to fully redeem 30% of their outstanding debt. On average, the lump sum amounts to 17.2% of pension wealth; in 5.5% of the scenarios, the participant is required to take the maximum lump sum of 20%.

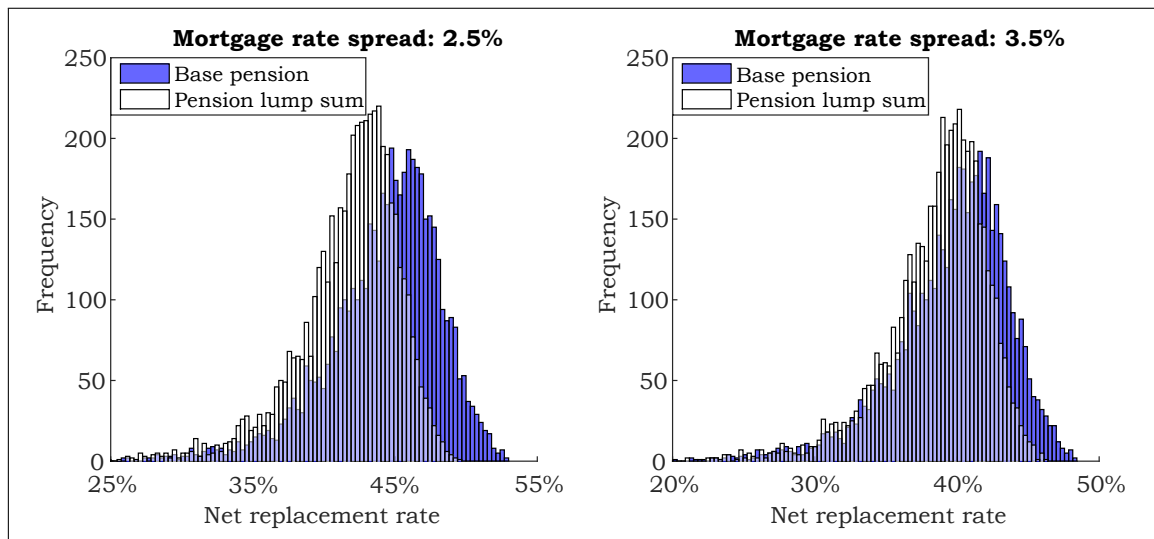


Figure 4.2: Reducing mortgage debt with a pension lump sum

This figure plots the distribution of replacement rates at retirement age for a participant with mainly traditional defined benefit entitlements, and partly defined contribution benefits. A partial lump sum of maximum 20% of second pillar pension wealth is used to redeem 30% of mortgage debt on an interest-only mortgage. The net replacement rate (pension minus interest expenses) is shown before and after mortgage redemption. The blue distribution is the base pension minus interest expenses on the full mortgage amount, the white distribution is the base pension minus lump sum redemption and renewed interest expenses. The higher the mortgage interest rate, the more beneficial it is to redeem mortgage debt (in absence of fiscal tax deduction).

As a result of partly depleting pension wealth, the expected labor earnings to be replaced by pension benefits is reduced to approximately 54.7% gross, compared to 62.7% before redemption. By redeeming mortgage debt however, interest expenses are reduced as well. In our example, the mortgage interest rate is calculated as the 10-year interest rate prevailing in the market with a spread of 2.5%, accounting for the risk of a payment default. Before mortgage debt is partly paid off, interest expenses in terms of replacement rate amount to 18.5% on average. With the ambition of redeeming 30% of outstanding debt, interest expenses could be cut down to 12.9%. The net effect on the replacement rate however is ambiguous. On the one hand, withdrawing a lump sum of pension wealth will directly reduce pension income available during retirement. On the other hand, a reduction in mortgage interest expenses will free up a part of income for consumption. Whether the net replacement rate is improved relative to the base scenario depends on the mortgage interest rate in the market. In Figure 4.2, we show the net replacement rate distribution for two levels of mortgage spreads. On the left-hand side, the base spread of 2.5% in excess of the 10-year interest rate is shown. The net effect of redeeming debt is negative: the post-redemption distribution is slightly shifted to the left compared to the pre-redemption distribution. That is, the decrease in replacement rate due to the lump-sum withdrawal is insufficiently compensated by the increase in replacement rate due to mortgage interest reductions. On the right-hand side, a spread of 3.5% is shown; the distributions slightly overlap, hinting at a relative improvement of the net replacement rate compared to the base spread. In principle, it holds that the higher the mortgage interest rate the homeowner is required to pay, the more beneficial it is to redeem mortgage debt (absent tax deductibility of interest expenses). Overall, the net effect is rather limited (which is a positive sign); by redeeming up to 30% of outstanding mortgage debt, the average net replacement rate was only reduced by 2.4 percentage points (from 44.2% to 41.8%).

In conclusion, older generations with high loan-to-value interest-only mortgages could benefit from flexibility as well by allowing them to take out a partial lump sum of pension entitlements in order to redeem their mortgage debt, and ultimately allow them to cut interest expenses and open up possibilities of refinancing.

## 5 Conclusion

Two trends in retirement wealth components are being observed in the Netherlands, specifically in pension and housing wealth. Following the trend from Dutch traditional defined benefit pension schemes to hybrid DB-DC and collective DC schemes, with prospects of individual DC elements, pension wealth at retirement is becoming more risky for participants due to less risks being borne by plan sponsors. Conversely, following the trend from high loan-to-value interest-only mortgages to low loan-to-value annuity mortgages in the Dutch housing market, net housing wealth at retirement is becoming less risky due to mandatory saving. These two opposing trends will have different impacts on different generations. Younger generations are faced with an imbalanced accumulation of wealth; there is a sizable probability of a low pension outcome in DC schemes, whilst the potential income from home surplus value is high for low loan-to-value annuity mortgages. Conversely, older generations may be confronted with large amounts of remaining mortgage debt due to homes financed with high loan-to-value interest-only mortgages, whilst having accrued a relatively certain pension in traditional DB schemes. In order to aid pension plan participants in realizing an adequate retirement income, there is a need for exchanging both wealth components by the use of flexible take-ups.

In our simulation study of retirement income streams, we have analyzed how and to what extent flexibility in the exchange of pension and housing wealth can contribute to an adequate pension for the young, and a reduced mortgage indebtedness for the old. We find that younger participants may benefit greatly from supplementing the possible outcome of a low pension by entering into a reverse mortgage contract. For younger participants, reverse mortgages can be an effective way of unlocking the surplus value in their homes. By allowing them to borrow against their accumulated home equity, a pension shortfall may be compensated in order to attain an adequate net replacement rate. Flexibility in exchanging home equity and pension wealth may not only benefit the young, but also the elderly, in an opposite way. By allowing older participants to withdraw a partial lump sum from their accrued pension rights, outstanding mortgage debt on interest-only mortgages may be considerably reduced whilst maintaining a lower, but still adequate net replacement rate; in turn, eligibility for mortgage refinancing may open up, allowing the elderly to remain in the home they are attached to.

## 6 References

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# A Appendix: Model

In this appendix the simulation model of retirement income streams is presented, representative for Dutch pension plan participants. The simulation model generates distributions of possible future outcomes of pension benefits for different types of pension schemes (following the trend from traditional DB to collective & individual DC), as well as scenarios of net housing wealth for different types of mortgages (following the trend from interest-only to annuity mortgages). The simulation model is based on APG's ALM model, and is used in conjunction with the risk model by van den Goorbergh, Steenbeek, Molenaar, & Vlaar (2011).

## A.1 Labor income

During employment participants earn labor income from which they pay pension premiums to the pension fund each year. At the start of employment, at age 25 ( $t = 1$ ), participant  $i$  earns labor income  $Y_{i,t}$  (base: €30000). Each period thereafter labor income is assumed to grow with wage growth  $w_t$ , the general wage growth in the economy, and a real wage growth factor  $u_{i,t}$  (base: 3-2-1-0% with intervals of 10 years), which defines the age-income profile of the participant. Participants earn labor income until the age of 66, after which they reach retirement age. Equation (A.1) below describes the labor income process.

$$Y_{i,t+1} = Y_{i,t} \cdot (1 + w_{t+1} + u_{i,t+1}) \quad (\text{A.1})$$

The level of labor income over the working period ultimately determines the amount of pension income from the second pillar one will receive upon retirement. In the collective scheme, pension benefits are based on a fixed accrual rate of labor income minus franchise each year (we assume gross salary equals pensionable salary), whereas in the individual scheme benefits are based on the amount of contributions made and the investment policy of those contributions over the lifetime. The accrual of second pillar pension benefits will be further described in later sections.

## A.2 Pension income

### A.2.1 First pillar: AOW

The first pillar in the Dutch pension system consists of a state old-age pension, the AOW (Algemene Ouderdomswet), which provides retired residents of the Netherlands a flat-rate pension benefit that in principle guarantees 70 percent of the net minimum wage, its main objective is poverty alleviation. This benefit serves as a basic pension, meant to be supplemented by the second pillar. Since its introduction, the intention has always been to entitle all Dutch residents to full AOW old-age pension rights if one has lived or worked in the Netherlands for the 50 years preceding retirement age. Entitlement to AOW pension is accumulated at a rate of two percent each year, leading to a 100 percent entitlement upon reaching retirement age, provided there are no gaps present. The first pillar can be regarded as a pay-as-you-go system, the AOW paid to current retirees is financed by contributions levied on the current working population, the taxpayers. If the amount of contributions is not sufficient to cover costs as a result of an aging population, the benefits will be partly financed out of public funds. The amount of benefit received is independent of any labor earnings or contributions paid in the past. In this study, we assume a participant has accrued full AOW benefits upon reaching retirement age; in addition, since the benefit is in principle linked to the statutory minimum wage, it is assumed to be growing with wage inflation  $w_t$ . The AOW pension benefit is defined as follows:

$$P_{t+1}^{AOW} = P_t^{AOW} \cdot (1 + w_{t+1}) \quad (\text{A.2})$$

The initial level of the benefit at retirement age is dependent on the AOW franchise  $F_t$  (base: €12650). The franchise is an amount subtracted from labor income, for which the participant does not accrue pension rights in the second pillar, since one will already receive a benefit from the first pillar. By design, the AOW benefit amounts to a fraction of seven-tenth of the franchise. The franchise is determined at the start of the simulation and increases each period with wage inflation, such that the pension base (pensionable salary minus franchise) in real terms remains constant absent real wage growth. The AOW benefit is received at retirement age 67 and thereafter.

### A.2.2 Second pillar: Collective pension scheme

The second pillar consists of a mandatory occupational pension system, whereby workers accrue pension rights based on their labor income; in this analysis we assume an average-wage scheme. The main objective of the second pillar pension is to maintain

the standard of living of the participant, since the first pillar only provides a minimum benefit to prevent old-age poverty. As opposed to the pay-as-you-go design in the first pillar, the second pillar is characterized by a funded system where accrued pension rights are backed by financial assets. In addition, there is a closer link between benefits and contributions on an individual level, known as actuarial fairness, whereas in the first pillar one receives a benefit irrespective of the contribution history. Since the scheme is collective, contributions of all working participants are pooled and invested according to the policy set by the fund's board, and accrued rights can be both positively and negatively indexed depending on the funding ratio (and type of scheme). In order to determine the pension income from the collective scheme, an actual pension fund should be simulated. Subsequently, we construct the fictitious pension fund and outline the simulation process of the accrual of benefits.

A funded collective scheme has assets  $A$  and liabilities  $L$ . The fund's assets grow with contributions from the working cohorts and decline with the pension payments made to the retired cohorts. Liabilities represent both the current accrued pension rights of workers, as well as the pension payments that are left to be made to current retirees in present value terms. The nominal funding ratio is defined as:

$$FR_t = \frac{A_t}{L_t} \quad (\text{A.3})$$

Participants accrue benefits based on a fixed accrual rate  $\epsilon$  (base: 1.875%) multiplied by the pension base  $Y_{i,t} - F_t$ . The accrued amount is expressed as a nominal deferred annuity, to be received at retirement age and each year thereafter. We can define the fund's initially accrued benefits  $B_t$  at  $t = 0$ , before the new working cohort aged 25 enters the fund (that is, before the time loop starts), as follows:

$$B_0 = \begin{bmatrix} 0 & \sum_{i=1}^1 \epsilon_i & \sum_{i=1}^2 \epsilon_i & \cdots & \sum_{i=1}^{42} \epsilon_i & \cdots & \sum_{i=1}^{42} \epsilon_i \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots \\ 0 & \sum_{i=1}^1 \epsilon_i & \sum_{i=1}^2 \epsilon_i & \cdots & \sum_{i=1}^{42} \epsilon_i & \cdots & \sum_{i=1}^{42} \epsilon_i \end{bmatrix} \quad (\text{A.4})$$

The columns of the accrued benefits matrix represent each age cohort (25 to 99), the rows represent each scenario (1 to 5,000). Participants accrue benefits as long as they are employed, for a maximum of 42 years. Each year a new working cohort enters the fund accruing new benefits and the last retired cohort leaves the fund as they pass away, shifting each column to the right. Depending on the type of collective scheme, every year nominal benefits can either be positively indexed for wage inflation and/or surplus sharing, or negatively indexed if the funding ratio falls below the required level. In order

to determine total liabilities of the fund, the accrued benefits matrix should be multiplied by the number of participants in each cohort and finally discounted back to the present. The population of each age cohort at a given time is given by:

$$Pop_{x+1,t+1}^{(g)} = p_{x,t}^{(g)} \cdot Pop_{x,t}^{(g)} \quad (\text{A.5})$$

That is, next period's number of participants with age  $x$  (where  $x = \{25, \dots, 99\}$ ) and gender  $g$  (male  $m$  or female  $f$ ), is calculated by multiplying the one year survival probability  $p_{x,t}^{(g)}$  by the current period's number of participants  $Pop_{x,t}^{(g)}$ . The one year survival probability  $p_{x,t}^{(g)}$  is calculated as  $1 - q_{x,t}^{(g)}$ , where  $q_{x,t}^{(g)}$  is the one year death probability, the probability that one will pass away at time  $t$ . Dutch population statistics and survival probabilities for each age cohort, including projections for the future, are supplied by Statistics Netherlands. Next, the nominal discount factor for age  $x$ , gender  $g$ , at time  $t$  is defined as:

$$DF_{x,t}^{(g)} = \sum_{s=\max(67-x,0)}^{99-x} {}_s p_{x,t}^{(g)} \cdot \left(1 + r_t^{(s)}\right)^{-s} \quad (\text{A.6})$$

where  ${}_s p_{x,t}^{(g)}$  is the  $s$ -year survival probability of a participant aged  $x$  at time  $t$ , and  $r_t^{(s)}$  the nominal interest rate with time to maturity  $s$  prevailing at time  $t$ . The nominal discount factor is a summation over a maximum of 33 years, the years for which participants receive their pension benefits; starting at  $\max(67 - x, 0)$ , the number of years preceding retirement, until  $99 - x$ , the number of years preceding death. In essence, the discount factor is the factor by which future pension payments must be multiplied in order to obtain the present value of accrued benefits, the liabilities of the fund. The initial discount factor matrix is constructed as follows:

$$DF_0^{(g)} = \begin{bmatrix} DF_{25,0}^{(g)} & DF_{26,0}^{(g)} & \dots & DF_{99,0}^{(g)} \\ \vdots & \vdots & \ddots & \vdots \\ DF_{25,0}^{(g)} & DF_{26,0}^{(g)} & \dots & DF_{99,0}^{(g)} \end{bmatrix} \quad (\text{A.7})$$

The fund's initial liabilities are calculated by an element-wise matrix multiplication of the accrued benefits  $B_0$  by the number of participants in each cohort,  $Pop_{x,0}^{(g)}$ , and finally by the appropriate discount factor  $DF_{x,0}^{(g)}$ , resulting in an initial liabilities matrix of the same dimensions ( $5000 \times 75$ ) where each column represents an age cohort and each row a scenario. Finally, all liabilities are summed up along each row for male and female participants, resulting in the total value of liabilities for each scenario at time zero:

$$L_0 = \sum_{x=25}^{99} L_0^{(m)} + \sum_{x=25}^{99} L_0^{(f)} \quad (\text{A.8})$$

The fund's initial assets  $A_0$  are calculated by multiplying the initial funding ratio (base: 100%) by the initially calculated liabilities  $L_0$ . In the subsequent years, the fund's assets grow with contributions  $C_{x,t}$  and investment returns  $r_t^C$ , and decline with pension payments  $B_{x,t}$ , as follows:

$$A_{t+1} = \left( A_t + \sum_{x=25}^{66} C_{x,t} \cdot Pop_{x,t}^{(g)} - \sum_{x=67}^{99} B_{x,t} \cdot Pop_{x,t}^{(g)} \right) \cdot (1 + r_{t+1}^C) \quad (\text{A.9})$$

The contribution rate of the collective scheme is uniform across all working cohorts and is calculated such that it equals the present value of total accrual rights for all participants, known as the 'doorsneepremie' in Dutch (base: approximately 20%). Pension benefits  $B_{x,t}$  are based on the accrual rate times pension base of the participants and indexation policy of the fund. Investment returns  $r_t^C$  depend on the asset allocation policy of the pension fund, which in this analysis is a two-asset equity/bond mix with 40 percent invested in equities and 60 percent in bonds.

Now that both assets and liabilities of the fund are defined, a time loop is started. Each year, a new working cohort of age 25 enters the fund and a retired cohort of age 99 leaves the fund, passing away at age 100. During the time loop, newly accrued benefits are added (accrual rate  $\epsilon$  times pension base  $Y_{i,t} - F_t$ ), population demographics and discount factors are updated, and subsequently assets and liabilities are recalculated according to the described processes, yielding a nominal funding ratio. Based on the nominal funding ratio  $FR_t$ , accrued benefits are adjusted according to the fund's indexation policy  $ind_t$ . Ultimately this results in the following, participant specific, accrued pension benefit:

$$P_{i,t+1}^C = P_{i,t}^C \cdot (1 + ind_{t+1}) + \epsilon \cdot (Y_{i,t+1} - F_{t+1}) \quad (\text{A.10})$$

The fund's indexation policy depends on the type of scheme. We analyze two schemes, traditional DB and collective DC. In the traditional DB scheme, indexed benefits are guaranteed and funding risks are absorbed by the contribution rate. Hence, each year benefits are adjusted for wage inflation  $w_t$ . In the collective DC scheme, indexation is conditional on the solvency of the fund and funding risks are absorbed by the adjustment of benefits. The collective DC indexation policy is split up into several funding ratio thresholds. Depending on the financial position of the fund, accrued benefits can either be cut, conditionally indexed, or fully indexed for wage inflation. The indexation policy is defined as follows:

$$ind_t = \begin{cases} \frac{FR_t - 100\%}{5} & \text{if } FR_t < 100\% \\ 0 & \text{if } 100\% \leq FR_t < 110\% \\ \frac{FR_t - 110\%}{135\% - 110\%} \cdot w_t & \text{if } 110\% \leq FR_t < 135\% \\ w_t & \text{if } FR_t \geq 135\% \end{cases} \quad (\text{A.11})$$

Since the contribution rate is fixed in this type of scheme, benefit cuts are the main instrument to improve the funding ratio in case it falls below the threshold of 100 percent. In such a scenario the cuts are smoothed over a five-year period; a form of risk sharing, so that current participants do not bear the entire burden of negative indexation. Additionally, in case the funding ratio exceeds 145 percent, participants may share in the surplus (smoothed over 10 years).

### A.2.3 Second pillar: Individual pension scheme

In this section we will define the pension income from the individual defined contribution scheme in the second pillar for a given participant. Firstly, we consider the value of the individual asset account. In principle, the account can be viewed as a personal savings accounts, where each year the participant's contributions are deposited and returns are added to the account value, as follows:

$$A_{i,t+1}^I = (A_{i,t}^I + c_t^I \cdot (Y_{i,t} - F_t)) \cdot (1 + r_{i,t+1}^I) \quad (\text{A.12})$$

where

$$r_{i,t+1}^I = \alpha_{i,t} \cdot r_{t+1}^S + (1 - \alpha_{i,t}) \cdot r_{t+1}^B \quad (\text{A.13})$$

The amount of contributions made to the asset account depends on the contribution rate  $c_t^I$  and the pension base  $Y_{i,t} - F_t$ . The contribution rate is fixed over the entire working period. The main factor influencing the pension outcome are the investment returns  $r_{i,t}^I$ , which differ between risk profiles. The participant has the choice between a risky asset, a stock, and a risk-free asset, a bond. The asset allocation policy can change over the life cycle, as denoted by  $\alpha_{i,t}$ . At retirement age a nominal annuity is purchased with the entire asset account value, guaranteeing a lifelong fixed income stream. The annuity payment at retirement age at time  $R$  is calculated as follows:

$$P_{i,R}^I = \frac{A_{i,R}^I}{DF_{67,R}^{(m)}} \quad (\text{A.14})$$

As shown by Equation (A.14), the annuity income  $P_{i,R}^I$  is calculated by dividing the individual asset account value at retirement age  $A_{i,R}^I$  by the annuity factor  $DF_{67,R}^{(m)}$ , resulting in a future value to be received as long as the participant is alive. The discount factor used to calculate the annuity rate is assumed to be based on male survival probabilities. In terms of risk, the numerator symbolizes investment risk, whereas the denominator symbolizes interest rate risk (macro longevity risk is not considered).

#### A.2.4 Fourth pillar: Housing wealth

The fourth pillar in our analysis consists of net housing wealth, the market value of a participant's home value in excess of remaining mortgage debt. The net housing wealth at retirement age is mainly dependent on the value of the initial house purchase, the house price appreciation rate, the type of mortgage used to finance the purchase, and the degree of leverage.

We assume that at age 37, a participant purchases a house with an initial value of four-and-a-half times his or her current labor income, financed by a mortgage. The past decade, the loan-to-income ratio in the Netherlands has hovered between four to five (Verbruggen, van der Molen, Jonk, Kakes, & Heeringa, 2015), depending on the prevailing mortgage interest rate. In the base scenario, the initial value of net housing wealth is fixed at zero. That is, the home purchase is entirely financed with mortgage debt (a loan-to-value ratio of one) with a time to maturity of 30 years. Over the course of time, the value of net housing wealth is dependent on the house price appreciation rate and mortgage payments. We consider two types of mortgages. Firstly, an interest-only mortgage whereby no periodic payments are made, hence the net housing wealth at retirement age is strictly dependent on the development of house prices. Secondly, an annuity (or linear) mortgage whereby each year mortgage debt is partly paid off such that at retirement age the net housing wealth equals the market value of the house. Next, we describe the development of house prices in the model.

The intuition behind the development of the house price index is that house prices are primarily determined by the maximum mortgage loan households are able to obtain. The maximum mortgage loan is related to the affordability of the mortgage for the household (whether the household can bear the periodic costs) and the willingness of banks to supply the loan. The affordability is related to the income of households and the costs of the mortgage, which is related to the interest rate and the type of mortgage (amount of repayment). The willingness of banks is related to the supervisory regime, the habit of banks, and their expectation for the future. Based on these ideas, the equilibrium relationship for the housing market is estimated using least squares, where the dependent variable is defined as the ratio of house prices over wages (loan-to-income)



and the independent variables are the ten year interest rate and yearly inflation. Over time, house prices may deviate from their equilibrium value depending on the state of the economy. In the short-term, determining variables are the short-term interest rate (signaling changes in the business cycle), the lagged level of the dividend yield (signaling past equity returns), and lagged commercial real estate returns. The state variables in the simulation model are described in the next section.

### A.3 Scenario set

The accumulation of pension and housing wealth as described in Appendix A.2 are dependent on the future outcomes of a number of risky variables: stock and bond returns, wage inflation, the term structure of interest rates, and the house price appreciation rate. The returns on stocks and bonds determine the value of financial assets for the collective and individual scheme, wage inflation determines the pension base for the calculation of accrual and contribution values in nominal terms, and the level of indexation for the collective scheme pension benefits. The term structure of interest rates is used to calculate discount factors to value accrued benefits of the collective scheme and to price the annuity of the individual scheme. The future outcomes of these variables are based on a Monte Carlo simulation of 5,000 possible economic scenarios; the initial values are representative for Q2 2015. The scenario set used in this analysis is derived from the risk model developed by van den Goorbergh, Steenbeek, Molenaar, & Vlaar (2011), which will be described in this section. The risk model comprises six stochastic and four deterministic state variables; the dynamics of the stochastic state variables are based on a quarterly vector autoregressive (VAR) model. Vector autoregressive models describe the dynamic structure of a set of variables. Their setup is such that current values of a set of variables are a linear function of their past values, hence are natural tools for forecasting (Lütkepohl, 2013). Zivot & Wang (2006) describe VAR models to be especially useful for describing the dynamic behavior of economic and financial time series and forecasting. The risk model by van den Goorbergh et al. (2011) is given by:

$$x_{t+1} = \begin{bmatrix} \pi_{t+1} \\ y_{t+1}^{(1)} \\ xS_{t+1} \\ dy_{t+1} \\ cS_{t+1} \\ mp_{t+1} \end{bmatrix} = c_t + \Gamma x_t + J_{t+1}\nu + \Sigma S_t^{1/2} \zeta_{t+1} \quad (\text{A.15})$$

where

$$c_t = (I_6 - \Gamma)(\mu_0 + \mu_{\bar{\pi}}\bar{\pi}_t) - p\nu \quad (\text{A.16})$$

$$\zeta_{t+1} \sim N(0, I_6) \quad (\text{A.17})$$

In Equation (A.15),  $\pi_t$  is the log of annual inflation in the Eurozone,  $y_t^{(1)}$  is the continuously compounded three-month Euribor,  $xs_t$  is the quarterly log excess return on the stock market,  $dy_t$  is the dividend yield in log percentages,  $cs_t$  is the credit spread between U.S. Baa rated bonds and treasuries also in log percentages, and  $mp_t$  is an unobserved variable termed the maturity preference. Maturity preference measures time-varying influences on bond prices, unrelated to the other state variables. Three of the stochastic state variables are known to help predict excess returns on stocks and bonds, namely the nominal short interest rate, dividend yield, and credit spread (Campbell & Viceira, 2002). The four deterministic state variables are the medium-term price assumption  $\bar{\pi}_t$  (an inflation target of two percent) and quarterly inflation  $\pi_t^q$  lagged one to three quarters.

The risk model by van den Goorbergh et al. (2011) accounts for a small chance of sudden panic in the market, modeled by the means of stochastic jumps;  $J_t$  is the jump indicator which equals one with probability  $p$  and zero otherwise, where  $\nu$  is a vector of mean jump sizes to measure the impact of the jumps. An event such as the recent credit crisis is an example of a jump in the market, a sudden change of sentiment; stock markets fall, risk-free interest rates decrease, and credit spreads widen. In addition to stochastic jumps, the model allows for time-varying volatilities; the diagonal matrix  $S_t$  represents the variance of the normally distributed shocks to the stochastic state variables. Time variation in volatilities is due to two factors: a monetary factor and a risk aversion factor, measuring monetary and real uncertainty, respectively. The addition of a low probability jump process and time varying volatilities is a great improvement to previously used models that considered crises both highly unlikely and volatilities to be constant; the past decade of crises with high volatility in financial markets has proven both assumptions to be wrong.

The term structure of interest rates is modeled as an affine model as part of the described risk model; an arbitrage-free model in which bond yields are affine (constant-plus-linear) functions of the state vector  $x_t$ . An affine term structure model hypothesizes that the term structure of interest rates, at any point in time, is a linear function of a set of variables. The dynamics of the stochastic state variables  $x_t$  (Equation (A.15)) govern the dynamics of the term structure in this case. The yield  $r_t^{(n)}$  of an  $n$ -period bond is calculated as:

$$r_t^{(n)} = \exp(A_n + B_n' x_t) - 1 \quad (\text{A.18})$$

for coefficients  $A_n$  and  $B_n$  that depend on the time to maturity  $n$ . The functions  $A_n$  and  $B_n$  make the yield equations consistent with each other for different maturities, and the state dynamics (Piazzesi, 2010). Both a nominal and real term structure can be constructed from this model; the resulting interest rates for each maturity are used to value the liabilities of the collective scheme and to determine the annuity payment given an asset value of the individual scheme.

Lastly, we define the wage growth variable. Since wage growth is not traded in the market, a different approach is used. In order to generate scenarios for this variable, wage growth is estimated using linear regression:

$$w_{t+1} = \alpha + \beta_1 w_t + \beta_2 \pi_{t+1} + \beta_3 y_t^{(1)} + \varepsilon_{t+1} \quad (\text{A.19})$$

where  $w_t$  is the lagged wage growth,  $\pi_{t+1}$  the inflation rate,  $y_t^{(1)}$  the short term interest rate and  $\varepsilon_{t+1}$  the error term. All variables are simulated for 5,000 scenarios over a 75-year period, the maximum lifetime of an individual aged 25 starting to accrue pension rights. The values of these variables are used to calculate the pension income for a participant; the AOW pension ( $P_t^{AOW}$ ) is a flat benefit which grows with wage growth in the economy, the collective pension ( $P_{i,t}^C$ ) will be simulated as part of a fictitious pension fund where risks are shared amongst participants through either the use of contribution (DB) or benefit (CDC) adjustments, and the individual DC pension ( $P_{i,t}^I$ ) is a nominal annuity for which its value will mainly depend on the investment policy during the accumulation phase and prevailing interest rates at retirement age.

### A.3.1 Summary statistics

In the previous section the evolution of the main economic variables is described, such as asset returns, inflation rates, and the term structure of interest rates. In this section, the simulations for these variables are summarized. Table A.1 presents summary statistics of 5,000 simulations over a 75-year period for the main economics variables used in the analysis, such as the mean, median, standard deviation, minimum and maximum values. Subsequently, Table A.2 displays the correlation matrix, indicating the linear relationship between the pairs of variables. Lastly, the mean term structure of interest rates at retirement age is plotted in Figure A.1.

Table A.1: Summary statistics

The table presents summary statistics for the main economic variables used in the analysis. Variables  $r^S$ ,  $r^B$ , and  $r^H$  denote the return on stocks, bonds, and housing respectively. Stock return simulations are based on the MSCI World Index, a broadly diversified stock market index that captures large- and mid-cap representation across 23 developed markets with 1,631 constituents, covering approximately 85 percent of market capitalization in each country. Simulations of a European government bond index (~6 year duration) are generated for bond returns. Simulations of the house price appreciation rate are based on Dutch house price data. Wage growth  $w$  follows from linear regression in Equation (A.19), price inflation  $i$  is simulated as a deterministic state variable with an inflation target of two percent.

Variable	Mean	Median	Standard dev.	Minimum	Maximum
$r^S$	8.19%	7.90%	19.18%	-74.74%	128.98%
$r^B$	1.49%	1.33%	2.98%	-16.93%	21.20%
$r^H$	2.06%	1.98%	5.96%	-24.78%	30.36%
$w$	1.76%	1.57%	1.21%	-0.47%	10.99%
$i$	1.34%	1.22%	1.39%	-3.57%	10.26%

Table A.2: Correlation matrix

The reported correlation coefficients indicate the strength of a linear relationship between the pairs of variables, and range between -1 (perfect negative correlation, move in opposite direction) and +1 (perfect positive correlation, move in lockstep) with 0 implying no linear dependency. The correlation coefficients are calculated over a 75-year series.

Variable	$r^S$	$r^B$	$r^H$	$w$	$i$
$r^S$	1.0000				
$r^B$	0.0059	1.0000			
$r^H$	0.1140	-0.1310	1.0000		
$w$	0.1272	0.0525	0.0700	1.0000	
$i$	0.0573	-0.0654	0.0916	0.5574	1.0000

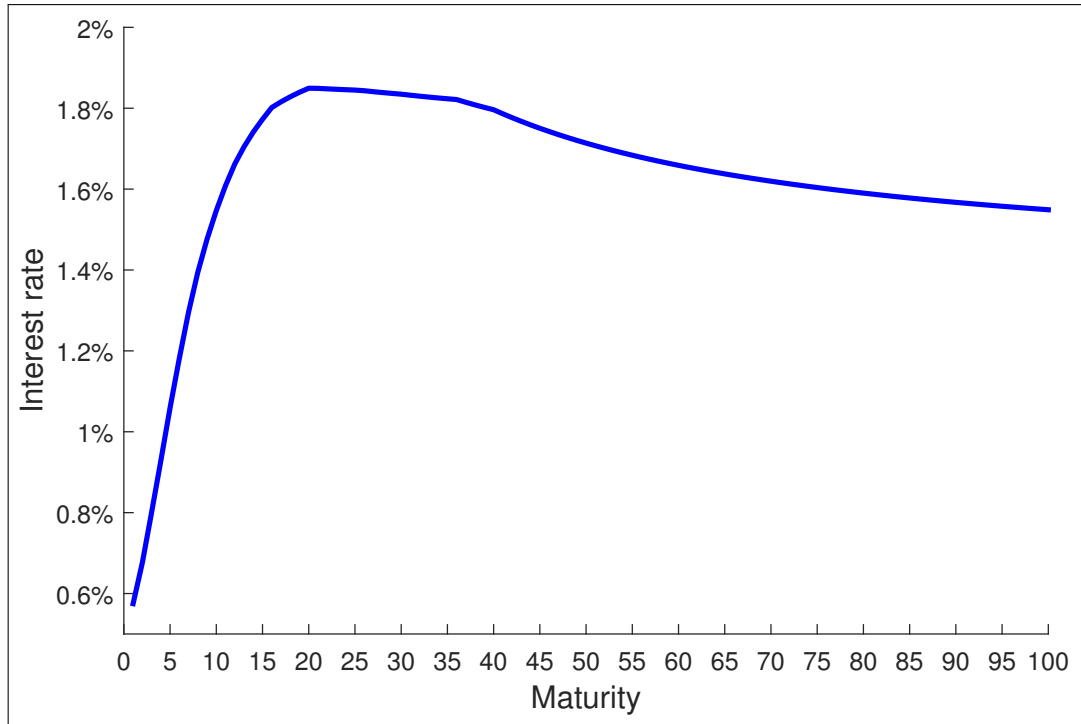


Figure A.1: Term structure of interest rates at retirement age

The presented graph is the average term structure over 5,000 economic scenarios, simulated at time  $t = 43$ , the retirement age for a participant aged 25 at the start of the time loop. The term structure of interest rates, or yield curve, is the key variable used to discount values to the present. In this case, it values the price of an annuity purchased at retirement age.